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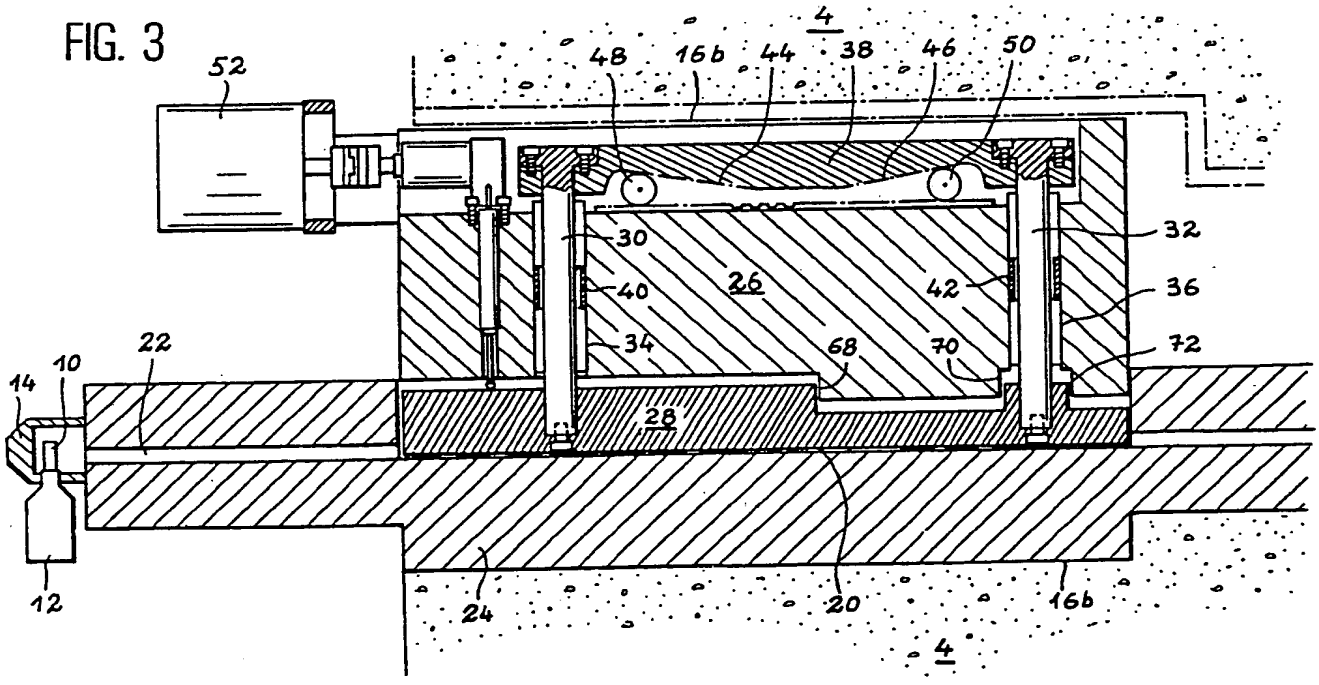
(54) Variable gamma ray collimator for fuel element measurements

(57) An adjustable collimation channel (20, 22) for use between a gamma-ray detector (10) and an irradiated fuel element comprises in a sleeve 16b:

- fixed parts (24) and (26)
- a further solid part (28), which is vertically mobile with the aid of ties (30, 32) joined at their tops by a connecting part (38) having on its lower face two ramps inclined in opposite directions (44, 46),
- two rollers (48, 50) resting on the upper horizontal surface of the support part (26)
- means (52) for symmetrically displacing in opposite directions the two rollers (48, 50) to raise or lower part (28) and thereby vary the height of a section of channel (20).

Displacement means (52) may be a stepping motor joined to a threaded rod which engages nuts fixed to each roller.

FIG. 3



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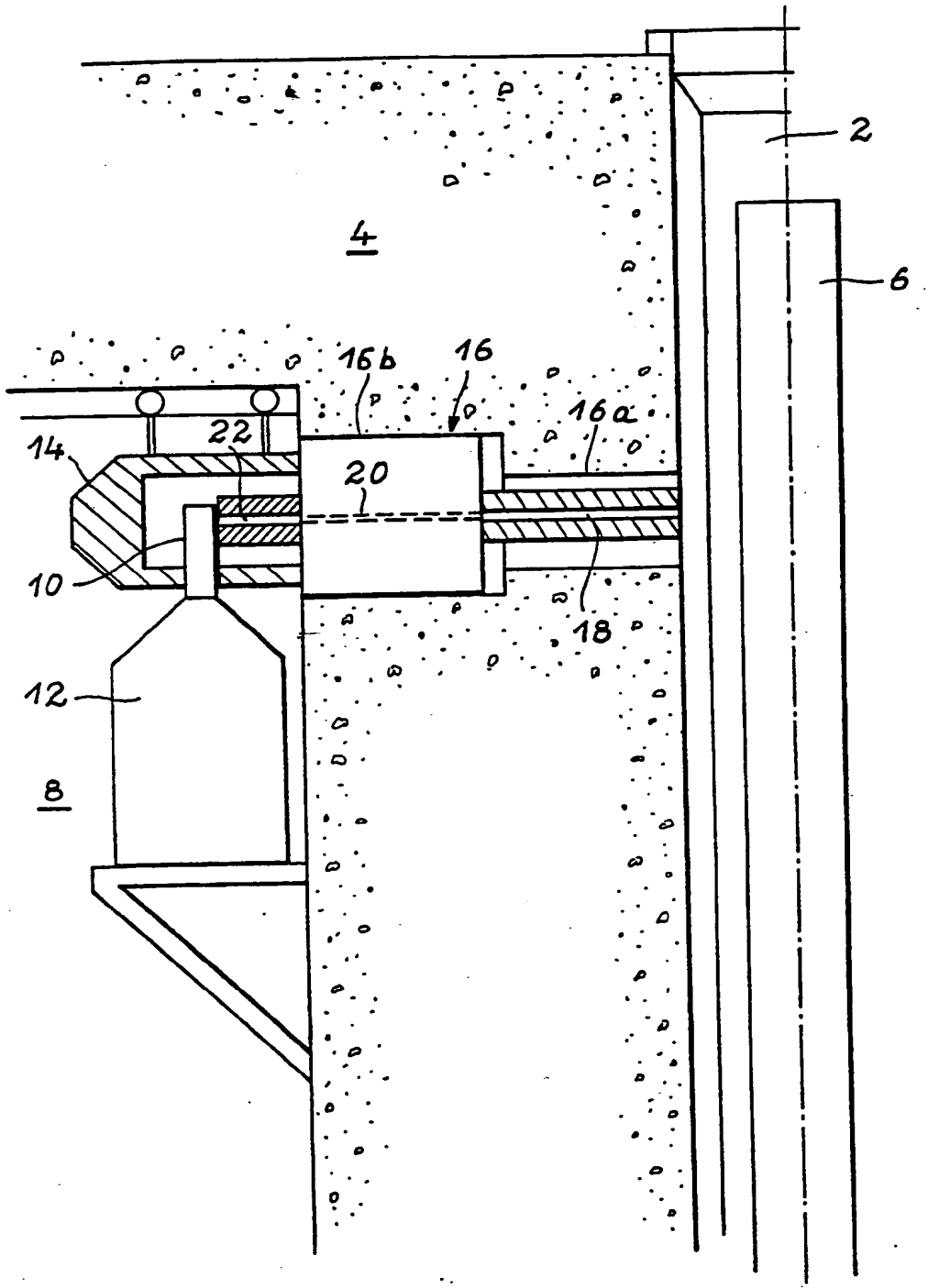

FIG. 1

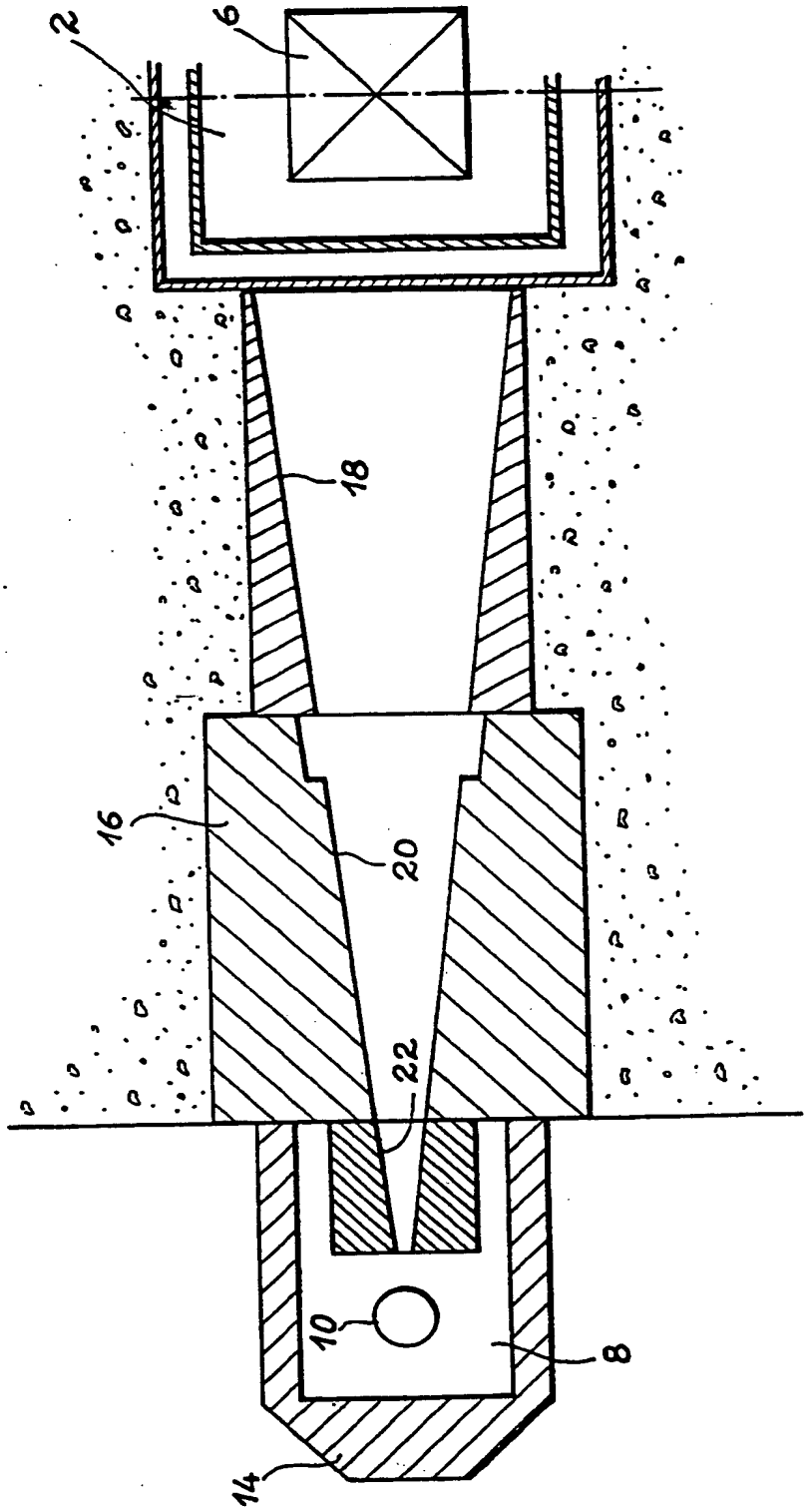

FIG. 2

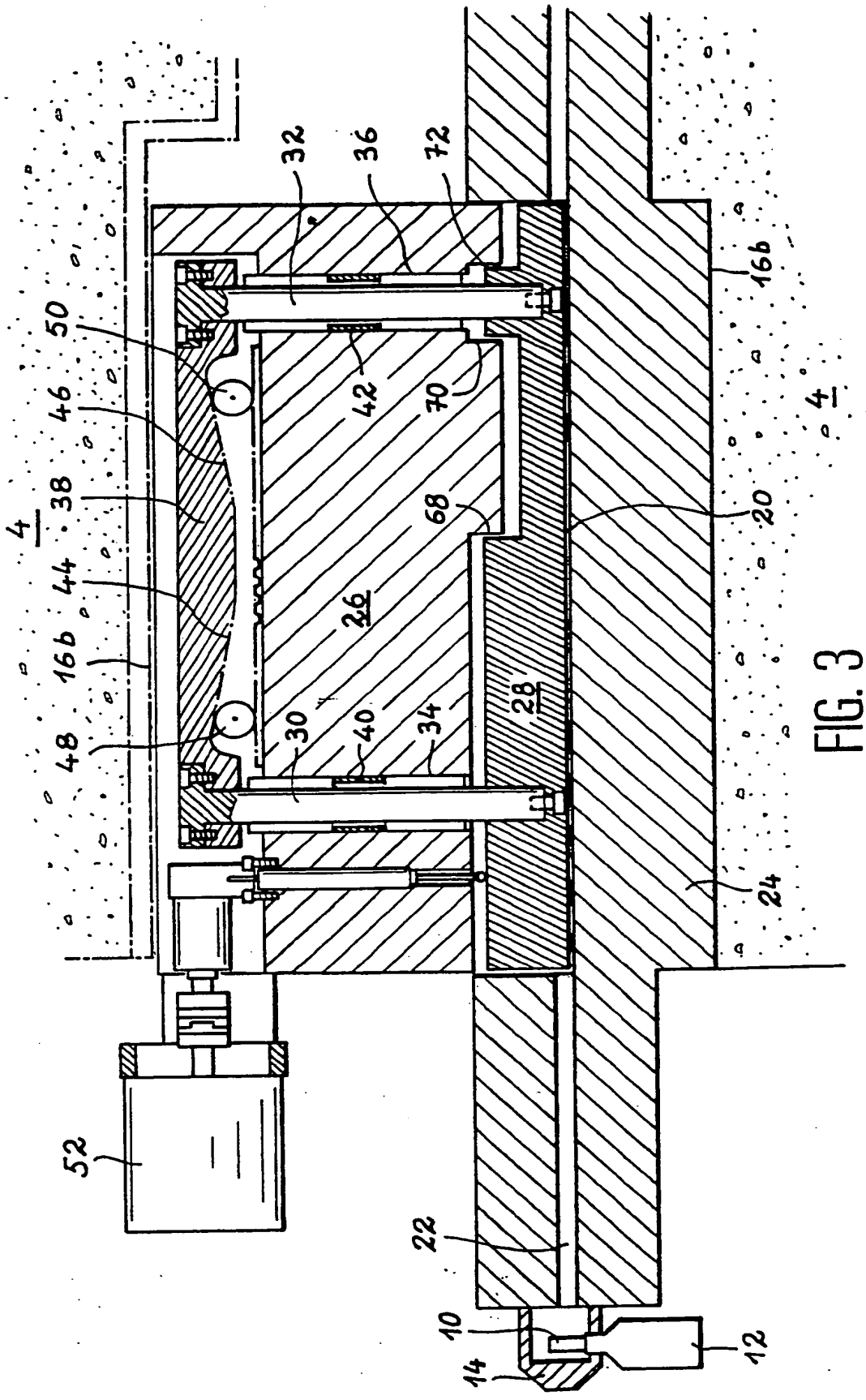
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FIG. 3

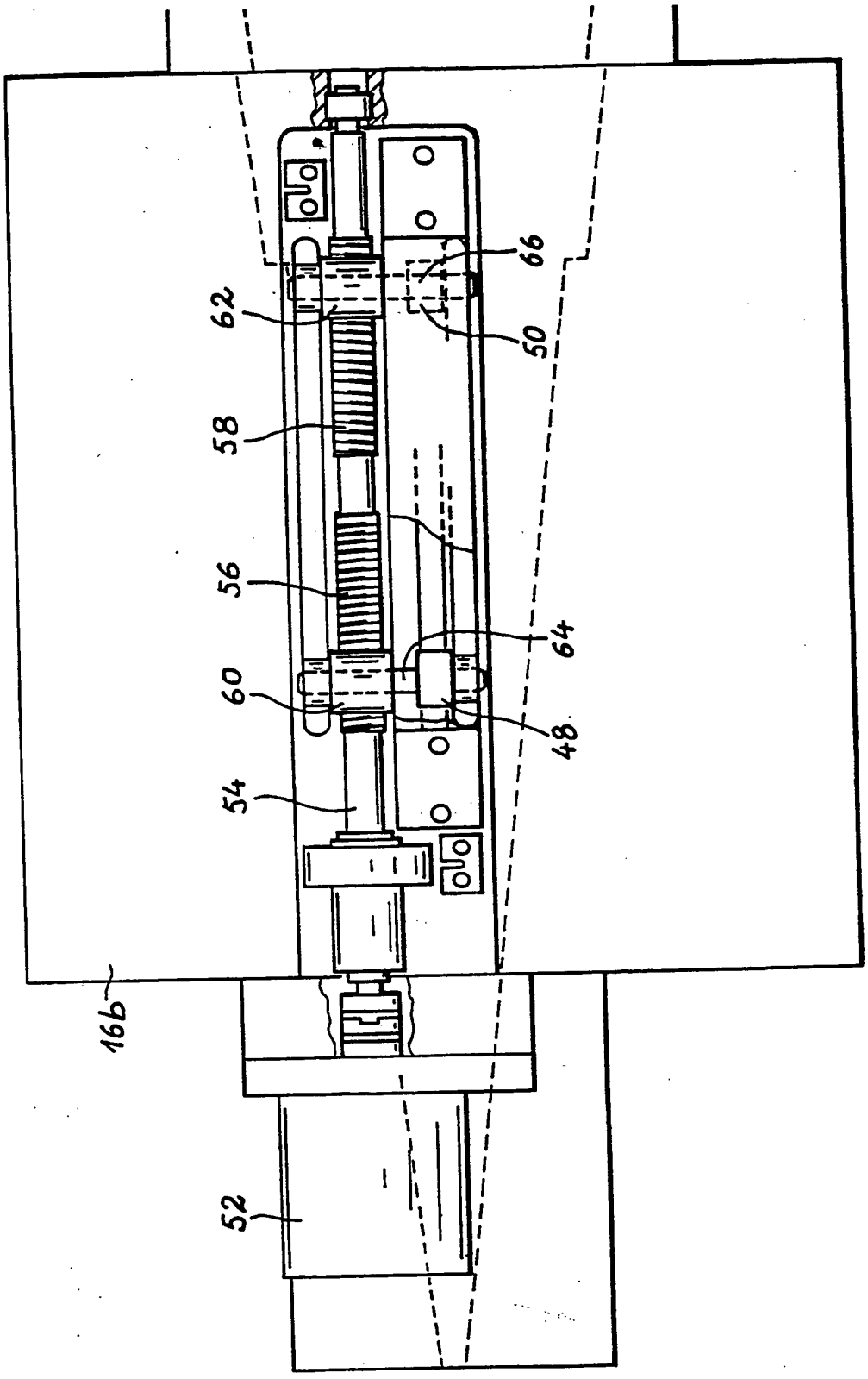

FIG. 4

MEANS FOR COLLIMATING A BEAM OF GAMMA RAYS EMITTED BY ONE EDGE OF AN IRRADIATED FUEL ELEMENT EXAMINED BY A DETECTOR

The present invention relates in general terms to methods for the examination of irradiated fuel elements from nuclear reactors on leaving which they must be stored and/or reprocessed.

No matter what procedure is adopted for such irradiated fuels once they have left the reactor of a nuclear power station, it is necessary that each of the fuel elements is characterized by a certain number of individual criteria. One of the said criteria essential for the identification thereof is the specific burn-up, i.e. the degree of exhaustion of the fissile material during the time which it has spent in the reactor. This specific burn-up inter alia provides direct information on the nature of the radioelements present in the fuel element and on the reciprocal proportion thereof.

Conventionally, information on the specific burn-up is obtained on the basis of the measurement of the gamma radiation flux emitted by the fuel element and processing the data concerning said flux using specialized software. On storing in this way spent fuel elements of different types and coming from reactors of different types, the gamma ray fluxes emitted by the different fuel elements can be very different as a function of the element type, the reactor type, the residence time in the reactor and the time spent by the element being deactivated in the pool where it is initially placed. In addition, the gamma ray fluxes emitted in this way are very high

fluxes and the fact that they have variable values does not facilitate the measurements.

Moreover, the measurement of the emitted gamma radiation must be accurate, because it is on the basis thereof that the entire fuel element reprocessing procedure is determined. In general terms, it is the knowledge of the specific burn-up of each fuel element, which does or does not authorize its subsequent reprocessing.

According to the prior art, the gamma flux emitted by a fuel element is measured by vertically displacing the said element e.g. in a pool and examining it by horizontal edges or regions of limited thickness with the aid of a gamma detector across a collimator, which defines the shape of the gamma beam which it is wished to measure. The biological protection necessary for this purpose is formed by concrete structures and lead shields.

In the known structures, the collimating slit has a limited thickness in the horizontal direction (it being this thickness which determines the thickness of the examined fuel element region) and having, in horizontal direction, a generally trapezoidal shape, whereof the large side is open in the vicinity of the fuel element region to be observed and whose small side issues onto the actual gamma radiation detector. In known installations, such collimators are formed from a slit having a not remotely regulatable opening. This characteristic has led to a number of disadvantages, including that which will now be described. When passing from the examination of a fuel element of a first type to that of a second type, it is always necessary to change the setting of the slit and modify the opening thereof to adapt it to each particular flux. However, in order

to carry out such a modification, it is necessary to completely dismantle the collimator, which greatly complicates the work involved and makes the operation particularly long and expensive.

The present invention more specifically relates to a means for collimating the beam of gamma rays emitted by an irradiated fuel element region to be examined by a detector and able, by means of a regulatable slit mobile collimator and whilst guaranteeing a total biological protection, ensures the measurement of the intensity of gamma sources with high and variable flux levels, the measurement taking place dry and the corresponding installation being fixed and being suitable for ensuring the protection of personnel.

The invention therefore relates to a means for collimating the beam of gamma rays emitted by an irradiated fuel element region examined by a detector, characterized in that it comprises in a sleeve formed in the concrete protective structure and connecting an observation chamber having the active part of the detector and a vertical shaft in which the fuel element to be observed is displaceable in vertical translation:

- a fixed, solid basic part surmounted by another solid, fixed support part, at a certain vertical distance above the basic part,
- in the space between the two aforementioned, fixed parts, a solid part which is vertically mobile with the aid of vertical ties connected in their upper part to a connecting part surmounting the support part,
- a system for the guidance in vertical translation of the ties, arranged respectively around each tie in vertical channels of the support part,

- a system of two rollers with a transverse axis resting on the upper horizontal surface of the support part and each in contact with one of two ramps inclined in opposite directions of the lower surface of the connecting part,
- means for symmetrically displacing in reverse directions the two aforementioned rollers in order to bring about the vertical translation of the mobile part and thus set the height of the collimating slit resulting from the vertical spacing between the basic part and the mobile part.

As in the prior art, the collimator slit generally has in plan a trapezoidal shape with a wide side directed towards the fuel element and a narrow side directed towards the detector, but it is constituted by the space between a fixed base and a part which is vertically mobile with respect to said fixed base, so that its thickness is regulatable at random in the vertical direction by easily used means.

According to an important feature of the present invention, the two rollers with a transverse axis resting on the upper horizontal surface of the support part are fixed to two nuts, each of which meshes with a thread located at the ends of a rod rotated by a stepping motor, each of said two threads being in opposition to the other.

According to another feature of the present invention, the upper surface of the vertically mobile part and the lower surface of the support part have complementary stair or step-like profiles permitting their vertical fitting together in order to oppose the existence of a rectilinear passage between the support part and the mobile part.

The invention is described in greater detail hereinafter relative to non-limitative embodiments and with reference to the attached drawings, wherein show:

Fig. 1 A vertical elevation of the complete observation system for the fuel element displaceable in its shaft using a detector through the collimating means according to the invention.

Fig. 2 A plan view of the collimating means level with the collimating slit.

Fig. 3 A detail of the vertical displacement means for the part which is vertically mobile with respect to the fixed base.

Fig. 4 A method for the displacement of the rollers in order to bring about the vertical translation of the moving part.

Fig. 1 shows in a vertical shaft 2 formed in a concrete structure 4 a fuel element 6 displaceable in vertical translation in the axis of the shaft 2 with the aid of means not forming part of the present invention and which are consequently not shown.

Within the concrete structure 4 there is an observation chamber 8 housing the detector 10 and the operating logistics 12, the sensitive part 10 of said detector being enclosed in a radiation-protecting enclosure 14, so that said chamber 8 can be accessible to the personnel using the structure.

Between the vertical shaft 2 and the observation chamber 8 a sleeve 16 is cut into the concrete 4 and one portion 16a thereof is fixed and has the first half 18 of the collimating slit and whose second portion 16b contains the mechanism for regulating the vertical size of the second half 20 of the collimating slit.

Fig. 2 shows in plan view the corresponding elements of Fig. 1 and reveals the trapezoidal shape of the collimating slit connecting the shaft 2 and the fuel element 6 to the detector 10. This collimating slit is in two fixed portions 18 and 22 and one portion mobile in the horizontal direction 20. In the plan view of Fig. 2, it is possible to see the trapezoidal shape of the three portions 18, 20, 22 of the collimating slit, whose wide side to the right of Fig. 2 issues onto the fuel element 6 and whose narrow side to the left of Fig. 2 issues onto the detector 10. With reference to Fig. 3 a description will now be given of the mechanism contained in the portion 16b of the sleeve 16 and by means of which the desired height for the collimating slit 20 is regulated to the desired value in accordance with the invention.

Fig. 3 shows the fixed base part 24 located in the sleeve 16b and made e.g. from solid steel. Above the fixed base 24 is located the solid support part 26 fixed with respect to the concrete structure 4. Between said two latter parts 24 and 26 is provided the mobile part 28 moving in vertical translation and consequently able to define the height of the collimating slit 20 within the narrow limits resulting from the presence of the two fixed parts 24, 26. This mobile part 28 moves in the following way. Two vertical ties 30, 32 traversing channels 34, 36 formed vertically in the support part 26 are anchored at their base in the mobile part 28 and connected at their apex to a connecting part 38 surmounting the support part 26. In the vertical channels 34, 36, guidance systems 40, 42 ensure the centring of the ties 30, 32 during their vertical displacement in the channels 34, 36 and the support part 26.

The vertical displacement of these ties 30, 32, which correlatively brings about that of the mobile part 28 and therefore the height of the collimating slit 20 takes place in the following way. The lower portion of the connecting part 38 is constituted by two ramps 44, 46 inclined in opposite directions and two rollers 48, 50, which will be described in greater detail relative to Fig. 4 and which are located with a horizontal rotation axis perpendicular to the plane of Fig. 3, between the upper horizontal portion of the support part 26 on which they can roll and for each of them on one of the two inclined ramps 44, 46. A stepping motor 52 is provided in conjunction with a mechanical system which will be described relative to Fig. 4 for rotating the rollers 48, 50 in opposite directions and so as to bring about, as a function of whether they move away or towards one another, the raising or lowering of the connecting part 38, thus bringing about the vertical translation of the mobile part 28.

On referring now to Fig. 4, a description will be given of one of the possible embodiments of the drive mechanism for the rollers 48 and 50. The drawing shows the sleeve 16b and the stepping motor 52 of Fig. 3. This stepping motor drives a horizontal shaft 54 carrying two screws 56, 58 having oppositely directed threads and in which respectively engage two nuts 60, 62. These two nuts carry on a transverse axis 64 for the first and 66 for the second, the rollers 48 and 50 of Fig. 3. It is obvious that if the rod 54 rotates under the influence of the stepping motor 52, the two nuts 60, 62 will be simultaneously translated in opposite directions, i.e. on moving towards or away from one another. In both cases, they also drive in opposite directions the rollers 48 and

50 bringing about, in conjunction with the inclined ramps 44, 46, the desired height displacement of the connecting part 38 and finally the mobile part 28.

On returning to Fig. 3, it should be noted that the mobile part 28 and the support part 26 have complementary stair or step-like profiles 68, 70, 72 in order to avoid the creation of a possible straight line leakage path for the gamma radiation from the shaft 2 to the observation chamber 8 of the overall apparatus. The height of these stairs 68, 70, 72 is calculated in such a way that when the height of the collimating slit (20) is minimum, the aforementioned nesting still exists.

Thus, according to the invention, it is possible to obtain a variable shape collimator, which in the horizontal direction makes it possible to see a complete fuel element region with a height e.g. between 0.1 and 10 mm, the setting to the desired value being supplied by the height given to the slit 20.

CLAIMS

1. Means for collimating the beam of gamma rays emitted by an irradiated fuel element region examined by a detector (10), characterized in that it comprises in a sleeve (16) formed in the concrete protective structure (4) and connecting an observation chamber (8) having the active part of the detector and a vertical shaft (2) in which the fuel element (6) to be observed is displaceable in vertical translation:

- a fixed, solid basic part (24) surmounted by another solid, fixed support part (26), at a certain vertical distance above the basic part,
- in the space between the two aforementioned, fixed parts, a solid part (28) which is vertically mobile with the aid of vertical ties (30, 32) connected in their upper part to a connecting part (38) surmounting the support part (26),
- a system (40, 42) for the guidance in vertical translation of the ties (30, 32), arranged respectively around each tie in vertical channels (34, 36) of the support part (26),
- a system of two rollers (48, 50) with a transverse axis resting on the upper horizontal surface of the support part (26) and each in contact with one of two ramps (44, 46) inclined in opposite directions of the lower surface of the connecting part (38),
- means (52, 54, 56, 58, 60, 62) for symmetrically displacing in reverse directions the two aforementioned rollers (48, 50) in order to bring about the vertical translation of the mobile part (28) and thus set the height of the collimating

slit (20) resulting from the vertical spacing between the basic part and the mobile part.

2. Collimating means according to claim 1, characterized in that the two rollers (48, 50) are fixed to two nuts (60, 62), each of which engages with a thread (56, 58) located at the ends of a rod (54) moved by a stepping motor (52), the directions of the two threads being opposite.

3. Collimating according to one of the claims 1 and 2, characterized in that the upper surface of the vertical mobile part (28) and the lower surface of the support part (26) have complementary stair-shaped profiles (68, 70, 72) permitting their vertical nesting in order to oppose the existence of a linear passage between the support part and the mobile part.

4. Collimating means according to either of the claims 1 and 3, characterized in that the collimating slit (20) has, in the plane of its width and its length, a trapezoidal shape, whereof the large side is turned towards the fuel element (6) and the small side towards the detector (10).

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9303752.1

Relevant Technical fields

(i) UK Cl (Edition L) G1A: (AMP,ATJ); G6C: (CDD,CDX) G6P: (P5B3, P6)

(ii) Int Cl (Edition 5) G01T 1/29; G21C 17/06; G21K 1/02, 1/04

Search Examiner
JOHN CAGE

Databases (see over)
(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search
29 MARCH 1993

Documents considered relevant following a search in respect of claims

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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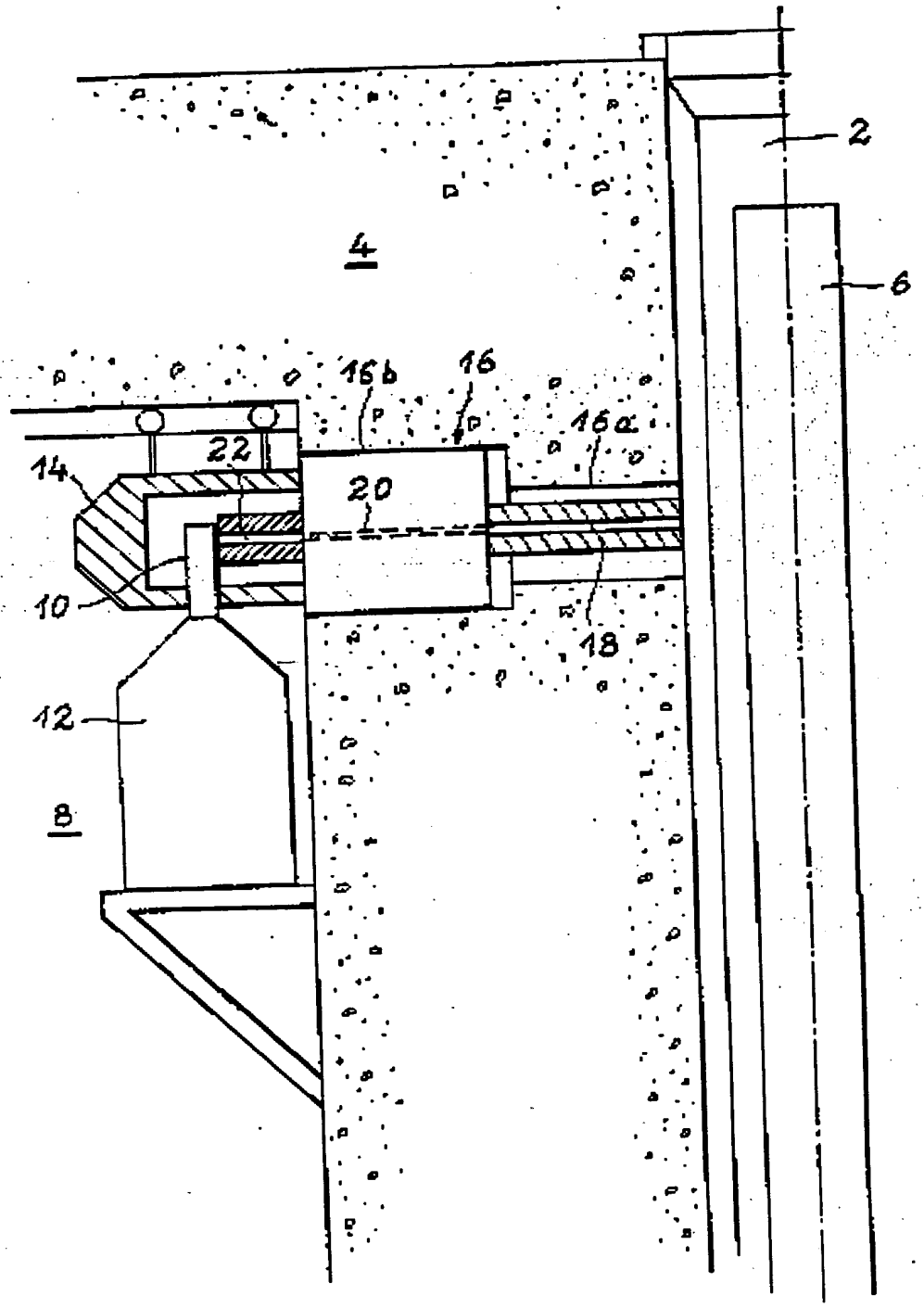

FIG. 1

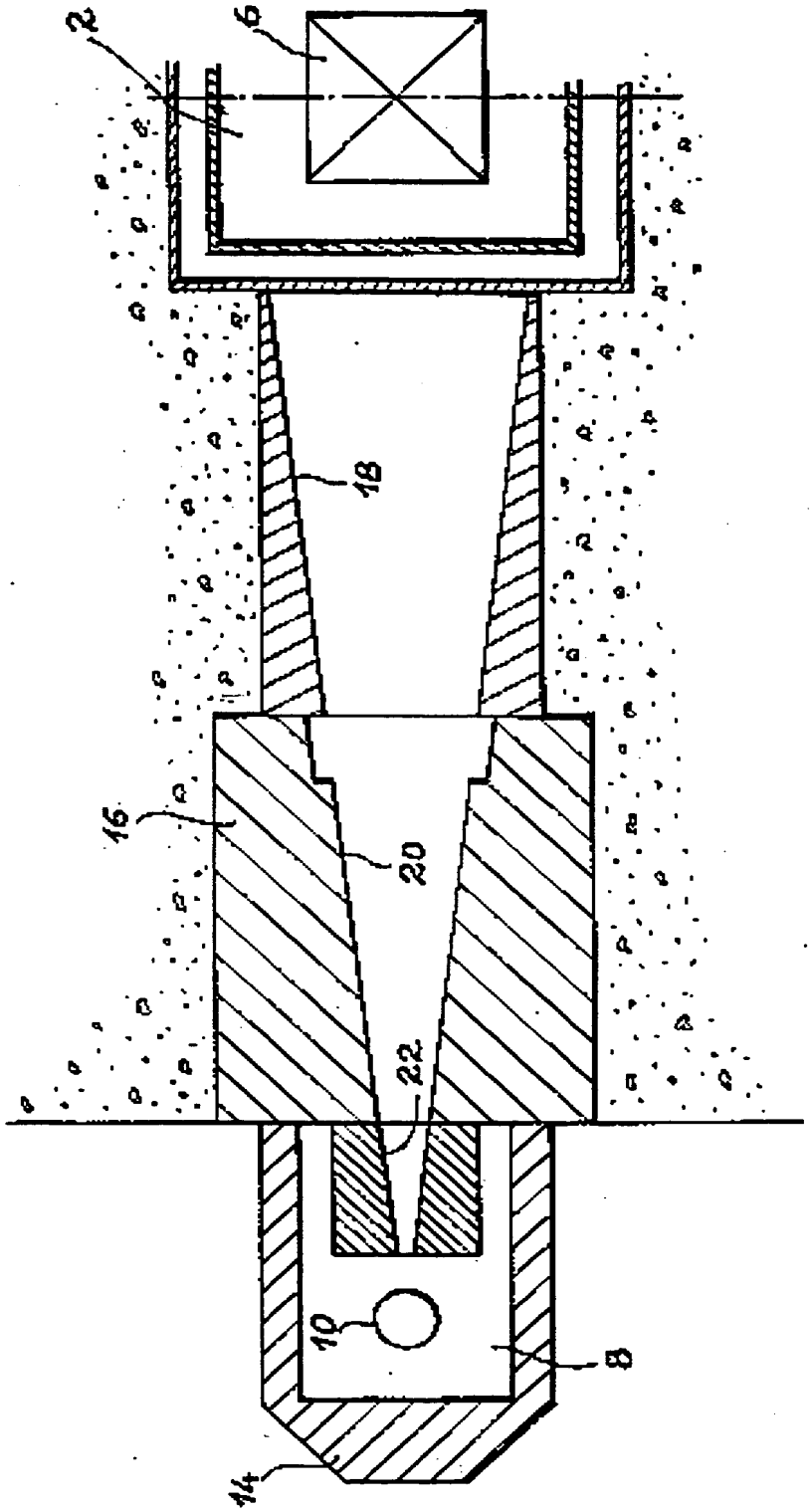

FIG. 2

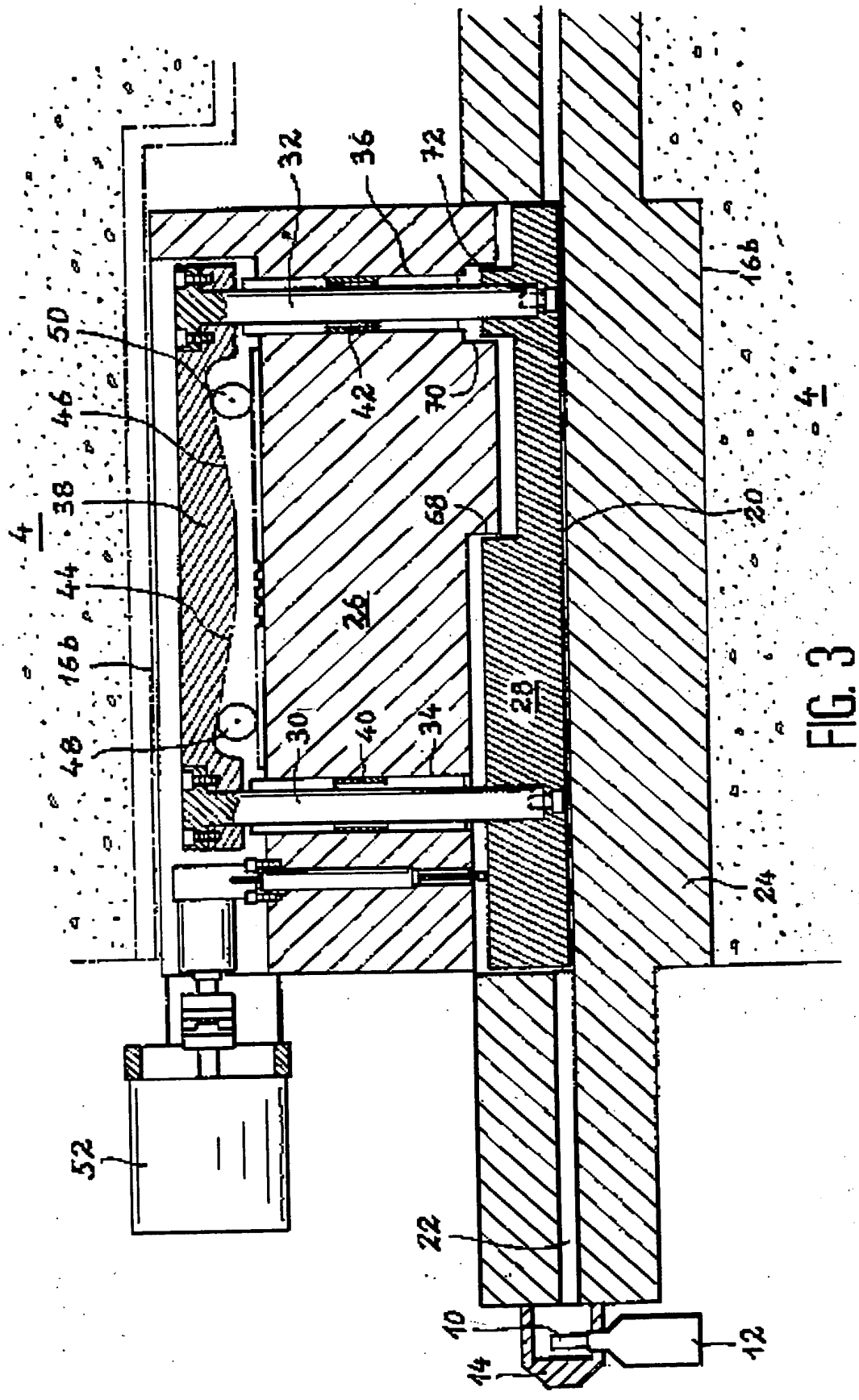
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FIG. 3

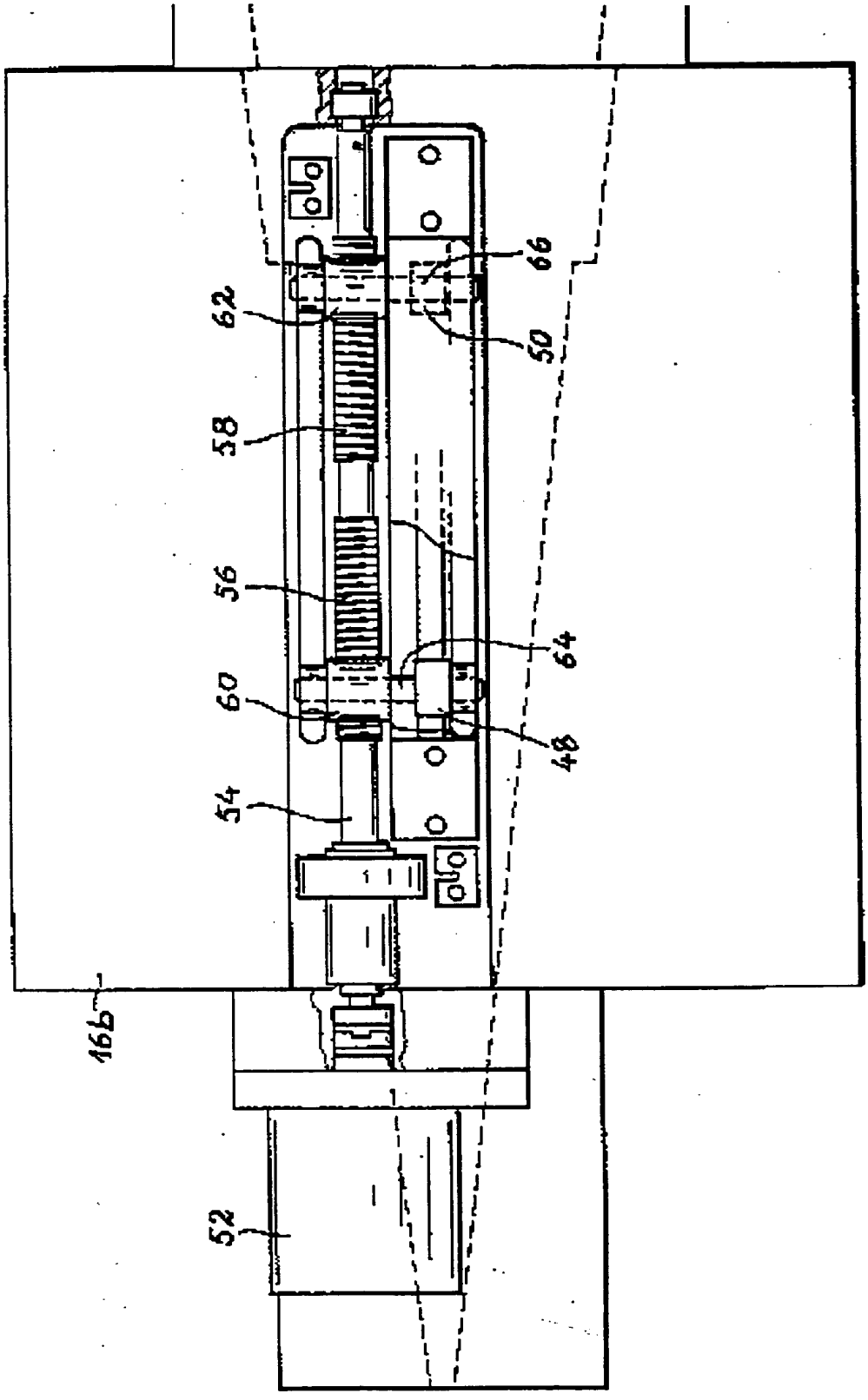

FIG. 4